PATENT SPECIFICATION

DRAWINGS ATTACHED

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1,117,553

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COMPLETE SPECIFICATION

Improvements in or relating to Barges

We, AIR LOGISTICS CORPORATION, a corporation incorporated under the laws of the State of California, United States of America, of 3600 East Foothill Boulevard, Pasadena, California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to barges, for example submersible or semi-submersible barges for shipment of materials through water.

In our co-pending application No. 48502/65 Serial No. 1,117,552 there is described an expansible and self-folding container having high structural strength. The container has a structure enabling expansion to large over-all dimensions while being self-folding as emptied so it assumes substantially reduced over-all dimensions. The present invention combines the expansible and self-folding features of this structure with a tubular structure so as to provide an expansible and self-folding barge for bulk shipment of liquids together with liquid or solid ballast materials. The ballast materials themselves may have economic value at the destination.

According to the present invention there is provided a barge for transporting materials through water, comprising a plurality of elongate sheets joined to one another along their longitudinal edges by hinge pieces of a bendable, flexible material so that an expansible and foldable container capable of carrying a fluid cargo is formed with the hinge pieces forming alternate inwardly and outwardly projecting folds, and an elongate tubular structure contained within and connected to the container so as to provide a compartment capable of carrying a material to act as ballast for the barge.

The advantages of the barge of the present invention and the manner of its use will be better understood from the following description of a preferred embodiment thereof, by way of example, with reference to the accompanying drawings in which:—

Fig. 1 is a schematic elevational view of an embodiment of the barge of the present invention in a folded condition;

Fig. 2 is a schematic enlarged sectional view showing the barge as seen along line 2—2 of Fig. 1 in a folded condition;

Fig. 3 is a plan view of a synthetic plastics sheet which forms a part of the barge of Fig. 1;

Fig. 4 is an enlarged fragmentary view showing a joint used to join sheets to form the barge of Fig. 1;

Fig. 5 is a schematic enlarged fragmentary sectional view generally taken along line 2—2 of Fig. 1 and showing a portion of the barge in a partially expanded condition;

Fig. 6 is an elevational view of the barge after it is fully expanded;

Fig. 7 is a sectional view generally taken along line 7—7 of Fig. 6 and showing a portion of the barge after it is in a fully expanded condition; and

Fig. 8 is an enlarged fragmentary view showing one of the joints and its associated sheets after the barge is in a fully expanded position.

With reference to Figs. 1 and 2, a barge 10, shown in its folded condition, includes an elongate semi-rigid tube 12. Bonded to a peripheral outer portion of the tube 12 are four sheets 14 which are co-extensive in length with the tube. Sheets 14 are joined along their longitudinal edges by joints or hinge pieces 16. It will be understood that the number of sheets bonded to the tube

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may be fewer or greater than four. The sheets constitute a part, and a means for attachment, of the expansible and self-folding container to be further described.

Although the tube may be formed from various materials, filament-wound fibre glass tubes provide the requisite rigidity and strength. Some degree of flexibility along the longitudinal dimension is required in the case of long tubes. The tube has a diameter sufficient to accommodate the amount of ballast required as commensurate with the amount and specific gravity of the liquid to be carried by the barge, and the type of water through which the barge is to move.

Auxiliary rigid tubes 18 are fitted within the tube 12 and are coextensive in length. The auxiliary tubes are used for air storage and for flotation control where the barge is operated fully submerged. Because of the length of the barge, suitable depth control equipment (not shown) is positioned at intervals along the length of the auxiliary tubes which are compartmented to provide localised control. The depth control equipment operates in conjunction with the associated auxiliary tubes according to well-known principles governing operation of submerged craft.

The outermost edge of each of the outermost sheets of sheets 14 is joined along its longitudinal edge to a sheet 20. Each sheet 20 is in turn joined along its longitudinal edge to the longitudinal edge of an adjacent identical sheet. Successive corresponding joining of additional sheets encompasses the tube 12 with a plurality of sheets in a corrugated pattern in the folded condition of the barge. Sheets 20 are not bonded to the cargo tube and are free to expand away from the outer surface of the tube.

A transition sheet 22 of the same material as sheets 20 may be joined, by an expanded joint of the type to be described, to the sheets 20 adjacent to it on either side. In the folded position, sheet 22 tends to be disposed circumferentially with respect to the tube 12, whereas sheets 20 tend to be disposed radially with respect to it. As shown in the drawing, sheet 22 enables a smooth transition between the plurality of sheets extending from the outermost edge of one sheet 14 and the plurality of sheets extending from the outermost edge of another sheet 14.

Sheets 20 are preferably formed of the same reinforced synthetic plastics material as the joint or hinge pieces which will be described. Since the sheets are not subject to an unusual amount of bending upon expansion, other more rigid materials may be employed for some barges. However, for large barges, e.g. of five million cubic meters capacity, the inherent structural characteristics of the reinforced synthetic plastics materials enable use of a thin wall structure for the barge which provides a significant economy in material costs.

As shown in Fig. 3 each sheet 20 has a longitudinal edge 23 and a longer parallel longitudinal edge 24. The longitudinal edges are joined by angled edges 26 to provide a tapered end portion 28 at opposite ends of sheet 20. It will be understood that edges 26 may also be curved to provide tapered end portions.

In the barge, each sheet 20 is joined along longitudinal edge 23 and angled edges 26 to the corresponding longitudinal edge and angled edges of an adjacent sheet by a joint to be described. Similarly, longitudinal edge 24 is joined to the corresponding longitudinal edge of another adjacent sheet. The sheets are joined to provide a series of longitudinal folds.

Joining of edges 26 of adjacent sheets at opposite ends of the sheets produces an envelope which defines a cargo container 30 between the interior surfaces of sheets 20 and the exterior surface of tube 12. The described barge can be made in a variety of sizes and may be utilised to provide barges of unusually large capacity. The reinforced synthetic plastics sheets may be four to six feet in width and as long as required to meet the intended utilisation.

The sheets are joined at their longitudinal edges by joint or hinge pieces 32 as shown in enlarged detail in Fig. 4. This joint piece is moulded from a reinforced laminated synthetic plastics material such as the product already described as sold under the trademark "Stratoglas". Sheets having an average thickness of about 1/16 inch (0.0625 inch) can be used, as such sheets, consisting of oriented lamina of parallel glass filaments bonded by an epoxy resin, provide a flexural yield strength as high as 180,000 p.s.i. in the direction of the filaments. The joint piece is formed by transversely folding a longitudinally extending strip in half along its longitudinal axis to provide in cross-section a pair of parallel legs 34 extending from a curved portion 36. A scarf 38 is formed in each of the legs, and a corresponding scarf 40 is formed in each of the longitudinal edges and angled edges of the plastic sheet. A scarf joint is produced between each leg of joint 32 and longitudinal edges and angled edges of the adjacent sheets by bonding the corresponding scarfs together with a suitable resin or the like.

It will be understood that joint or hinge pieces corresponding in shape to pieces 32, as shown in Fig. 4, can be integrally formed as part of the synthetic plastics sheets providing these sheets have the characteristics requisite for the joint material, i.e. self folding and expansible. Therefore the term "joint piece" or "hinge piece" where used in this specification is intended to include

such joint or hinge pieces when integrally formed as a part of the sheets. With large barges however, it is more convenient to form the joint pieces separately and secure them to the sheets, as has been described.

As to the material from which the joints are formed, the ratio (S_M/E) of the maximum bending stress (S_M) to the modulus of elasticity (E) should be as high as possible. It can be shown that this ratio can be equated to the ratio (T/R) of the thickness of the material (T) to the radius of curvature (R) of the portion 36 of the joint. To meet the requirements for the barge of the present invention, the thickness must be great enough to provide the requisite strength while the radius of curvature must be small enough to provide minimum over-all dimensions in the folded condition of the container. Filament-reinforced laminated synthetic plastics materials of the type described meet these requirements. Their S_M/E ratio is between 0.03 and 0.04. With a material thickness of 0.1 inch, a radius of curvature between 2.5 inches to 3.3 inches can be obtained with retention of the self-folding characteristic.

In operation, the tube 12 of the transport is loaded at the point of origin with a material to act as ballast, preferably a material having utility and economic value at the destination and so also forming a part of the cargo. Examples of solid ballast materials that could be utilised in large amounts are coal, phosphate rock, construction sand, crushed rock or solid rock. By closing the ends of the tube 12 slurries of some of the above-enumerated materials may be utilised as well as liquids having densities greater than salt water.

After loading of ballast, cargo container 30 between the tube 12 and the interior of sheets 20 is filled with liquid cargo. As additional liquid is pumped into the enclosure, the force exerted on the interior surfaces of sheets 20 begins to expand the envelope of the barge. The sheets are moved outwardly between their longitudinal edges as the joint pieces are unfolded. Fig. 5 is a fragmentary view showing a portion of the envelope in a partially expanded position. Continued addition of liquid expands the envelope to the fully expanded position in which, as indicated by the fragmentary view in Fig. 7, the envelope has a substantially elliptical or circular cross-section. As particularly shown in Fig. 8, the flexural modulus of the material of the joint pieces enables the joint pieces to be opened so that each leg of the joint piece is displaced from each other almost 90° from its position when the container is in a folded position. However, even with this degree of bending, the yield point of the material is not exceeded so that no permanent deformation of the joint pieces and sheets defining the enclosure takes place.

In its fully expanded position, the angled edges of the adjacent sheets form tapered and substantially conical sections 42 at opposite ends of the container, as particularly shown in Fig. 6.

The barge is then moved either by towing or its own propulsion means (not shown) to the destination. During transit, the tapered leading end of the barge reduces hydrodynamic resistance. As the liquid is removed from the enclosure at the destination, the self folding characteristic of the container causes it to return to a folded condition, as shown in Figs. 1 and 2. The ballast material can be removed by conventional unloading means. Once emptied, the barge can be returned without cargo to the point of origin in its folded state.

In a modified form of the preferred embodiment of the present invention, a diaphragm 44 (shown by a dotted line in Fig. 6) is inserted within the container 30 to form a separate compartment in the region indicated by reference character 46. This compartment may be pressurised to a higher pressure than that within the remainder of the container 30. The end section containing the pressurised compartment forms the leading portion of the barge during transit through water. The pressurized compartment acts to prevent deformation of the end section.

The structural characteristics of the barge of the present invention enable construction of barges having the dimensional capability for moving large quantities of liquids. For example, a barge 6000 feet long with a 200-foot diameter in its expanded condition is capable of carrying about 5,250,000 cubic metres of liquid. This size transport requires 18,000 h.p. to produce a five-knot cruising speed. Where the liquid to be transported is fresh water, and shipment is through salt water, the buoyancy provided by the fresh water cargo determines the submerged weight of cargo that is to be carried in the tube 12 or auxiliary tubes. For the dimensions given above, where the liquid carried is fresh water, about 104,000 long tons of submerged material acting as ballast could be carried in sea water.

With the barge of the present invention, a number of different container configurations, size, cargo combinations, and loading methods may be used. The barges may be large fully-submersible or semi-submersible types capable of carrying single or multiple liquid cargoes. Smaller units may be adapted to be beachable so that the barge may be drawn up on land at the point of destination and serve as a storage container until its liquid cargo is removed. Further, flexible partitions may be provided within the cargo container 30 and/or tube 12 so that, if de-

sired, incompatible liquid cargoes can be carried in separated enclosures.

WHAT WE CLAIM IS:—

1. A barge for transporting materials through water, comprising a plurality of elongate sheets joined to one another along their longitudinal edges by hinge pieces of a bendable, flexible material so that an expansible and foldable container capable of carrying a fluid cargo is formed with the hinge pieces forming alternate inwardly and outwardly projecting folds, and an elongate tubular structure contained within and connected to the container so as to provide a compartment capable of carrying a material to act as ballast for the barge.

2. A barge as claimed in claim 1 wherein said elongate tubular structure is a semi-rigid tube.

3. A barge as claimed in claim 1 or 2 wherein said elongate tubular structure contains flotation control tubes.

4. A barge as claimed in any one of the preceding claims including separate bonding means for bonding together the ends of the sheets to form approximately conical end portions on said container.

5. A barge as claimed in claim 4, including a flexible diaparhgm located inside said container for forming a sealed compartment in one of said conical end portions.

6. A barge substantially according to either one of the embodiments hereinbefore described with reference to the accompanying drawings.

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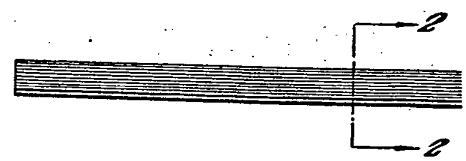
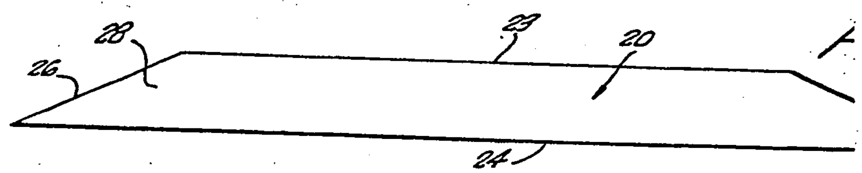
FIG_1_





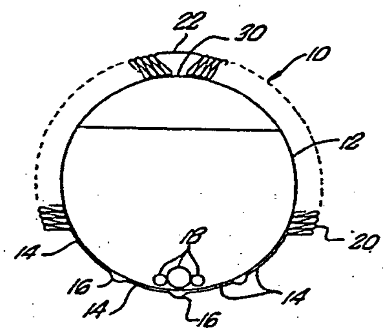
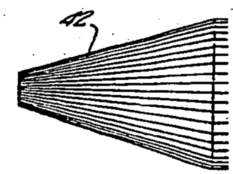


FIG_2_

FIG_6_



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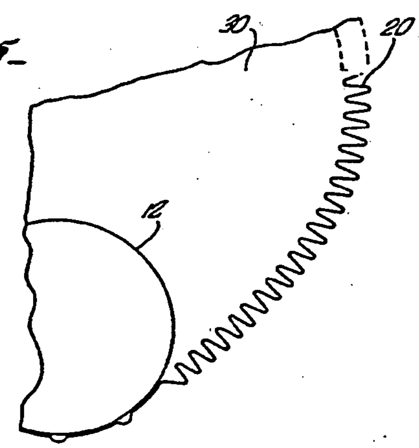

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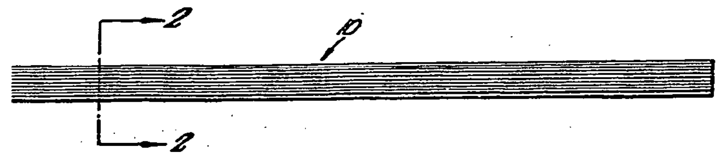

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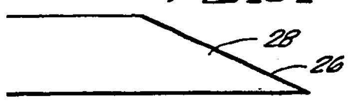


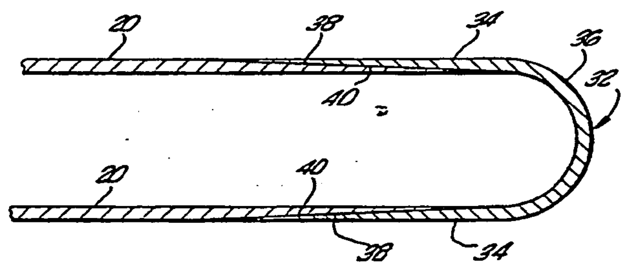
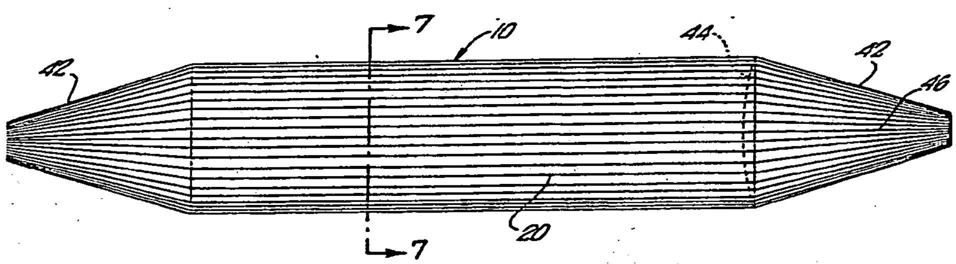
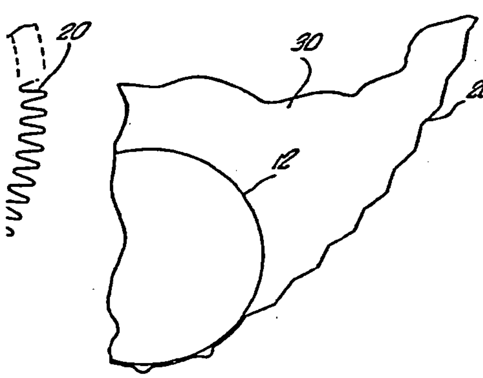


FIG_4_





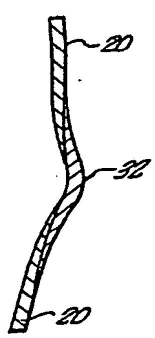


FIG_7_

FIG_8_

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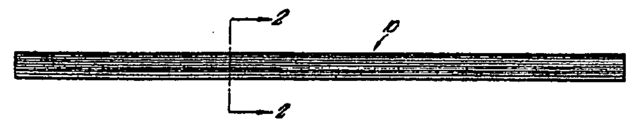
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG. 1.



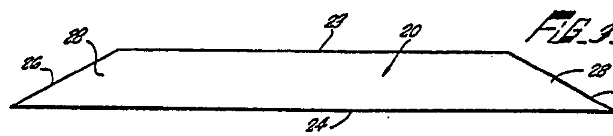


FIG. 3.

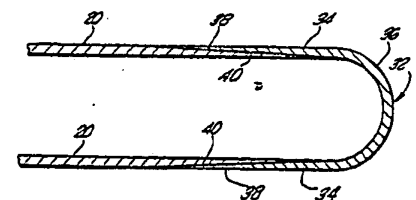


FIG. 4.

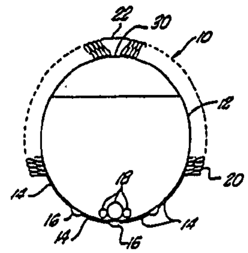


FIG. 2.

FIG. 6.

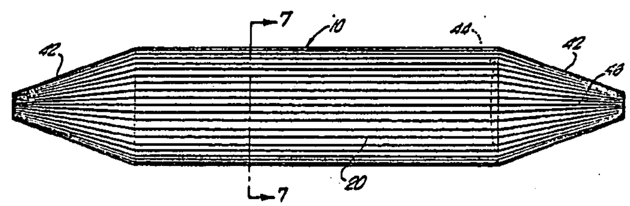
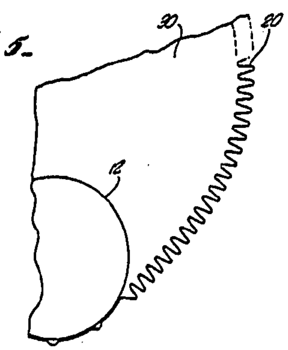


FIG. 5.



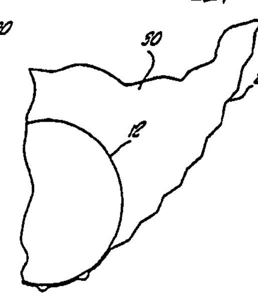


FIG. 7.

FIG. 8.

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